Wavelet analysis of Ring and Jet-like events for ^{32}S-Ag/Br Interactions at 200A GeV/c

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Introduction

The genuine multiparticle correlations originating from some collective effects may appear in individual events. There exists a method of the wavelet analysis which reveals the local properties of any pattern in an individual event on various scales. The method fulfills the outlined requirements, providing practical mathematical apparatus to perform multi scale analysis. By choosing the strongest fluctuations, one may chuck out statistical fluctuations and observe those dynamic ones which exceed the statistical component. Dremin speculated [1,2] about possible Cherenkov gluons relying on experimental observation of the positive real part of the elastic forward scattering amplitude of all hadronic processes at high energies. This is a necessary condition for such process because in the commonly used formula for the refractivity index its excess over 1 is proportional to this real part. However, later he noticed that for such thin targets as nuclei the similar effect can appear due to small confinement length thus giving us a new tool for its estimate. If several gluons are emitted and each of them generates a mini-jet, the ring-like substructure will be observed in the target diagram. If the number of emitted gluons is not large, we will see several jets correlated in their polar, but not in the azimuthal angle. If the number of correlated particles within the ring is large enough, it would result in spikes in the pseudorapidity distributions. The wavelet analysis is well suited for this purpose because it clearly resolves the local properties of a pattern on the event-by-event basis by choosing the so-called Heisenberg windows. In this paper we have performed wavelet analysis to get an idea about the relevant scales and preferred pseudorapidities into two subgroups of particles – ring-like and jet-like events for pions multiplicity emitted from ^{32}S-Ag/Br interactions at 200A GeV [3]. In general, the continuous wavelet transform of function *f(x)* has the form $W_\psi(a,b)f = \frac{1}{\sqrt{C_\psi}}\int_{-\infty}^{\infty} f(x)\psi_{a,b}(x)dx$, where x is a studied quantity and C_Ψ is a normalizing constant. The functions $\psi_{a,b}(x) = a^{-\frac{1}{2}}\psi(\frac{x-b}{a})$ are shifted and/or dilated derivations of mother wavelet [4] function $\Psi(x)$ characterized by translation parameter b and dilation parameter or scale a. The coefficients W_Ψ (a,b) can be interpreted as contributions (amplitudes) of wavelets $\Psi_{a,b}$ to spectrum f(x). The choice of the wavelet depends on the problem studied and is not unique. As an example of continuous wavelets, let us mention the so-called `Mexican hat' wavelet, which is the second derivative of the Gaussian function ($g_2 = (1-x^2)e^{-\frac{x^2}{2}}$). In our analyses we use g_2 as the mother wavelet since the signals of approximately Gaussian-like shape are expected. We have chosen the variable x as η and the distribution of pseudorapidities is given by $f(\eta) = \frac{dn}{d\eta} = \frac{1}{N}\sum_{i=1}^{N}\delta(\eta-\eta_i)$, where N is the number of particles in a studied data sample and η_i is pseudorapidity of i^{th} particle. Data sample can mean either a few events or one single event or only a part of event. The wavelet transform of the function f(η) takes on the form $W_\psi(a,b)f = \frac{1}{N}\sum_{i=1}^{N} a^{-1/2}\psi(\frac{(\eta_i-b)}{a})$. If one study the wavelet η spectrum at the large scale, only coarse features of the pseudorapidity distribution will be pulled out whereas at the small scale the complicated fine structure will be extracted. Wavelet g_2 pseudorapidity spectra of the ring and jet-like events are presented in Fig.1 for two different scales 'a' (0.2 and 0.5). The maximums in the spectra in Fig. 1 are related to the preferred pseudorapidities of groups of particles. From the study we may say that the numbers of particles included to each kind of structure is different. Prevailing scales of an event can be obtained by studying the maximums of the scalogram.

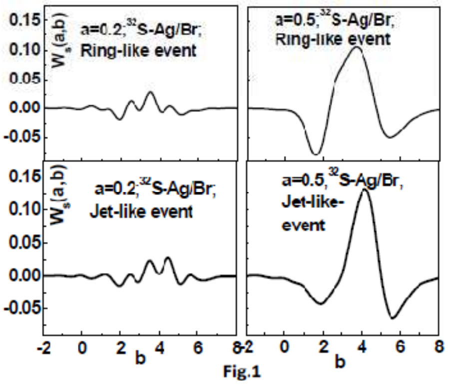

Fig.1

We have shown the scalograms of ring and jet-like events in Fig.2. Each scalogram, shown in the figure, is only for one event taken from each set of events. Scalograms suggest the presence of only one relevant scale in each set of event. The scale range lies between 0.07 to 0.2 and we have focused our interest in that region in our next analysis. Ring-like structures are expected to occur most likely only at a few distinguished pseudorapidities and are assumed to appear at similar scales in all the events. These preferred pseudorapidities would be manifested by local maximums in the event-by-event wavelet pseudorapidity spectra of large sample of events.

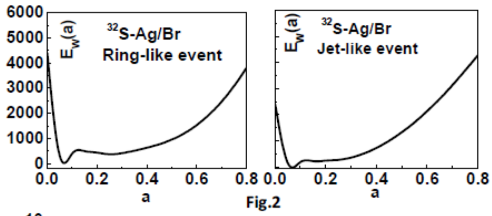

Fig.2

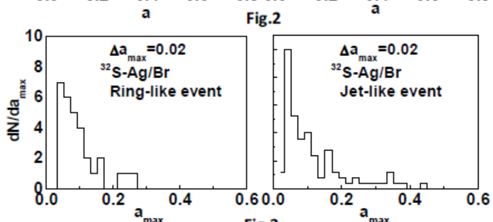

Fig.3

If ring-like structures are present in the studied data then distinctive scales and preferred pseudorapidities come into view frequently and systematically in many events but will not appear arbitrarily. This can be investigated by creating the spectra of relevant scales. Fig.3 presents the distribution of maximum points localized in the scalograms of ring and jet like events for ^{32}S-Ag/Br interactions. Some poor signal of relevant scales are identified at $0.15 \leq a \leq 0.17$ for ring-like events and $0.09 \leq a \leq 0.17$ for jet like events. The presence of ring-like structure would be signaled by peaks or at least bumps in the pseudorapidity distributions. These signatures could be amplified in the distributions of b_{max}, which is a pseudorapidity coordinate of wavelet maximums $W_{\Psi}(a_{max},b_{max})$. The b_{max} spectra plotted for a particular scale interval ($0.05 < a \leq 0.1$) is presented in Fig.4. Moreover, the analogous b_{max} distributions are displayed for the FRITIOF and Monte Carlo model to make some helpful comparisons. The b_{max} spectra in Fig.4 are found irregular in the examined scale band. Local maximums which can be named irregularities are quite abundant, though not all of them are statistically relevant. Therefore, not all the irregularities can be associated with multiparticle collective flows. We can see that the experimental distribution has some peaks over the corresponding model distribution and is quite prominent for the FRITIOF model distribution. This is quite satisfactory for the ring-like events rather than the jet-like events.

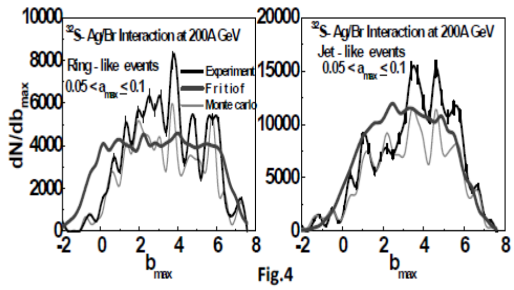

Fig.4

So, we get some conclusive idea of the dominant scale and preferred pseudorapidities for ring & jet like events for ^{32}S-Ag/Br interactions at 200A GeV/c . As well as the preferred pseudorapidity region for the occurrence of ring and jet-like events are indirectly found out in the corresponding b_{max} distributions.

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